The Radula and Reproductive System of *Olea hansineensis* Agersborg, 1923

(Gastropoda : Opisthobranchia : Sacoglossa)

BY

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(3 Text figures)

INTRODUCTION

Olea hansineensis Agersborg, 1923 is a small sacoglossan sea-slug that feeds on the eggs of tectibranchs. Its skin is creamy-white in colour, strongly mottled with a brownish-black pigment; its external features are shown in Figure 1. *Olea* was discovered by Agersborg in the vicinity of Friday Harbor, Washington, where it can still be found. AGERSBORG's description (1923) contained only a few remarks about the internal anatomy of *Olea*, among which was the statement that a radula was totally absent. THIELE (1931) placed *Olea* in the order Sacoglossa in a family by itself, the Oleidae. HOFFMANN (1936) doubted the wisdom of this, since so little was known about *Olea* and it lacked the distinctive feature of a sacoglossan radula.

Although the taxonomic position of *Olea* was uncertain, nearly half a century elapsed before anything new was added to Agersborg's original description. CRANE (1971) described clearly how *Olea* feeds on the eggs of *Haminoea, Aglaja* and *Gastropteron* and gave an interesting account of its reproductive behaviour. She confirmed that a radula was absent. The present paper describes some anatomical details of *Olea* that are of special taxonomic importance. It maintains that *Olea* has, in fact, a radula, though it is minute and much reduced. The reproductive system is described and brief notes are added about the external features and the central nervous system so that the systematic position of *Olea* may now be reviewed.

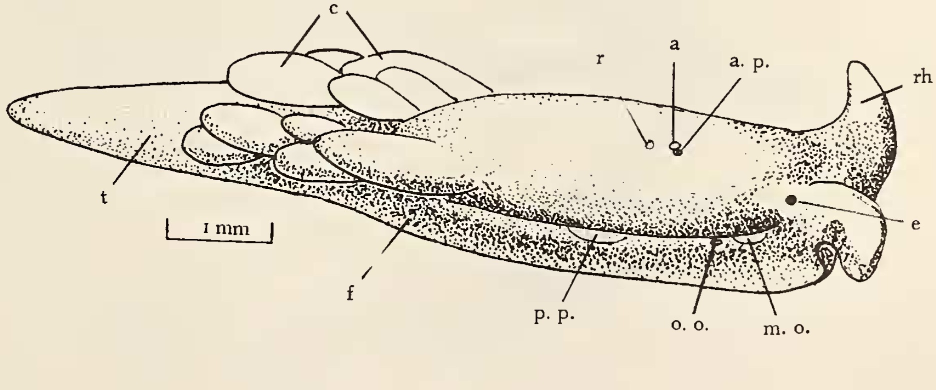

Figure 1

Olea hansineensis – after CRANE, 1971

a – anus a. p. – anal pocket c – cerata e – eye
f – foot m. o. – male opening o. o. – oviducal opening
p. p. – pale patch of skin over the closed bursa copulatrix
r – renal opening rh – rhinophoral lobe t – tail
(The labial lobes are placed ventro-laterally around the mouth)

SOURCE of MATERIAL

Preserved: Two specimens collected by T. E. Thompson in 1969 from near Friday Harbor, San Juan Island, Washington. Four specimens obtained by H. Lemche in 1972 from the aquaria of Friday Harbor Marine Laboratory.
Other Material: Photographs of the living animal (figures 1 and 2; Crane, 1971).

RADULA

Olea has a barrel-shaped buccal mass that shows no external signs of an ascus, or radular sac. The walls of the barrel are too thick to be cleared by Berlese's fluid and it requires treatment with a solution of caustic potash to render them transparent. If now a stereoscopic microscope is used at a magnification of $\times 50$, a tiny splinter may be seen lying in a forward position beneath the dilated pharynx. Higher magnification will reveal that the cuticular splinter is a minute, reduced radula. For the present study 5 radular mounts were carefully prepared and examined. The reader is requested to refer to Figure 2 when reading the following description.

In some species of Sacoglossa the first tooth differs from the rest. It may be minute and somewhat conical in shape, and, if it is retained on the ribbon in the radular sac, it points in approximately the opposite direction to the neighbouring teeth. Gascoigne & Sartory (1974) showed that *Limapontia capitata* (Müller, 1773) and *Hermaea dendritica* (Alder & Hancock, 1855) each have a first tooth of this kind, and so has *Olea*. The second tooth of *Olea* is rod-like and may give support to the first tooth. The next 3 teeth are easily recognisable as adult sacoglossan teeth. Tooth No. 3 is the largest adult tooth and in this it resembles the 3rd tooth of *Calliopaea oophaga* Lemche, 1974, another egg-eating sacoglossan. Tooth No. 5 is like an adult tooth of *Hermaea*; Figure 2 shows the back, or ventral side of the tooth with 2 strong ribs converging to form a strongly pointed tip. Between the ribs on the ventral side is a depression extending from near the tip to the base of the tooth. This tooth-pattern is seen in *Hermaea*, *Elysia*, *Lobiger* and *Oxynoe*. *Stiliger* and *Limapontia* have a different ventral pattern that consists of a median ridge along the crown, the ridge dividing to 2 lateral ones near the beginning of the base.

The 5th tooth lies across the entrance to the radular caecum, there being no teeth to press it forwards into position of a leading tooth. The radular caecum is empty, though its cuticular wall shows impressions of attempted tooth formation; sometimes the faint outline of a complete tooth may be seen.

The radulae that were examined varied considerably. One had an extra tooth on the lower limb between No. 3 and No. 4, another had 3 fully formed teeth at the blind end of the radular caecum, whilst in a third the 1st and

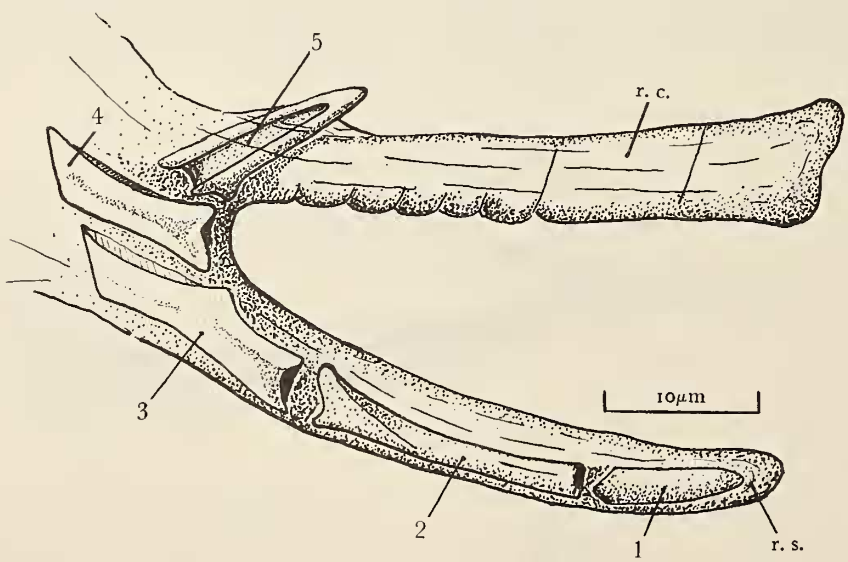

Figure 2

The radula of *Olea hansineensis*

r. c. – radular caecum r. s. – radular sac

2nd teeth were of aberrant shape. Nevertheless they were all sacoglossan radulae in that each consisted of a single row of teeth bent in a $<$ shape and the teeth were recognisably sacoglossan in shape.

The radula may be functional for a brief period after the veliger larva settles. Then the need for food is greatest for the animal is growing rapidly and it may be incapable of ingesting eggs. Teeth Nos. 1 and 2 might serve for general grubbing around; Nos. 3 and 4 appear capable of piercing young algal growth and tiny rhizoids. Thus the radula could tide the animal over the first 2 or 3 weeks of post-larval life. Or the teeth may be used when *Olea* makes the initial puncture through the outer part of an egg-string. Once the radula has ceased to function, the formation of additional teeth would be suppressed.

But it is also possible that the radula is not functional at any time. The small number of teeth, their incomplete suppression and the occasional misshapen appearance of the 1st and 2nd tooth support this view. What is needed to settle the question is a study of post-larval feeding in *Olea,* and this could be extended to include some other sacoglossans in which the first 2 or 3 teeth (juvenile teeth) differ from the rest.

REPRODUCTIVE SYSTEM

The reproductive system of *Olea* resembles in many ways that of *Limapontia cocksi* (Alder & Hancock, 1848) (principal synonyms: *Acteonia cocksi* Alder & Hancock, 1848 and *Acteonia senestra* (Quatrefages, 1844). To avoid overburdening the text with too much descriptive matter, a functional interpretation of the reproductive system is appended to Figure 3. This is inferred from what is known about *L. cocksi* and *L. capitata* (Gascoigne, 1956) — no direct evidence is available for *Olea* at present. In Figure 3 simple descriptive terms are used and their classical synonyms are given in parentheses; the large oviduct has been displaced to the left and drawn as if semitransparent in order to show the underlying structures.

The wall of the ampulla is thick and contains elastic and muscle fibres; their contraction would assist in the transport of sperm or eggs when the animal is sexually active. The wall of the bursa and its duct are also thick and their contraction may help to direct foreign sperm towards the fertilization junction. By comparison the wall of the genital receptacle is thin and it is probably incapable of ejecting the material stored in the receptacle. The bursa copulatrix is closed and lies next to the body wall, therefore the penial style must penetrate the body wall and inject sperm into the bursa.

Olea and *Limapontia cocksi* have similar reproductive systems. Each has a male opening and an oviducal opening, and the bursa is closed. The arrangement of ducts around the fertilization junction is alike, except that *L. cocksi* has an oviducal loop, which is not present in *Olea.* The ovotestis of *L. cocksi* consists of 6 large spherical follicles, whereas *Olea* has about 200 small follicles. This is to be expected, because in *L. cocksi* the veliger is suppressed and development is direct, but in *Olea* the specialised method of feeding restricts the habitat, so that, as in the parasitic mode of life, there must be increased reproduction if the species is to survive.

The penial style of *Olea* resembles those of *Limapontia cocksi* and *L. capitata* in general shape. It is $120\,\mu\text{m}$ long; the styles of *L. cocksi* and *L. capitata* are of length $70\,\mu\text{m}$. When not in use, the styles of the last 2 species are each housed in a depression formed in the tip of the penis; the style of *Olea* lies across the tip of the penis when housed inside the animal. The external opening of the style of *Olea* is more sharply pointed than in the other 2 species. It is of the penetrant type and its function is briefly discussed by Gascoigne (1974b).

ADDITIONAL NOTES

External Features: Agersborg (1923) remarked that the head of *Olea* is like that of *Limapontia capitata,* but it more closely resembles that of *Stiliger niger* Lemche, 1960. And the Limapontiidae do not possess cerata, whereas they are common in the Stiligeridae. The pattern of the dorsal openings is like that of *L. capitata,* but a similar pattern is probably present in some species of the Stiligeridae.

Central Nervous System: The Stiligeridae, Limapontiidae and Oleidae have the same type of central nervous system. The visceral loop is short and bears only 2 ganglia (Gascoigne, 1974a).

METHODS

The dissections were made by micro-manipulation without the use of any elaborate apparatus. Since the radulae were so small, the standard method of preparing a mount was considerably modified. The method employed is given in full so that other workers may adapt it to suit their own needs.

Each buccal mass was placed in a watch glass containing a 5% solution of NaOH. A trace of Azo-black was added by means of a cocktail stick. The solution was

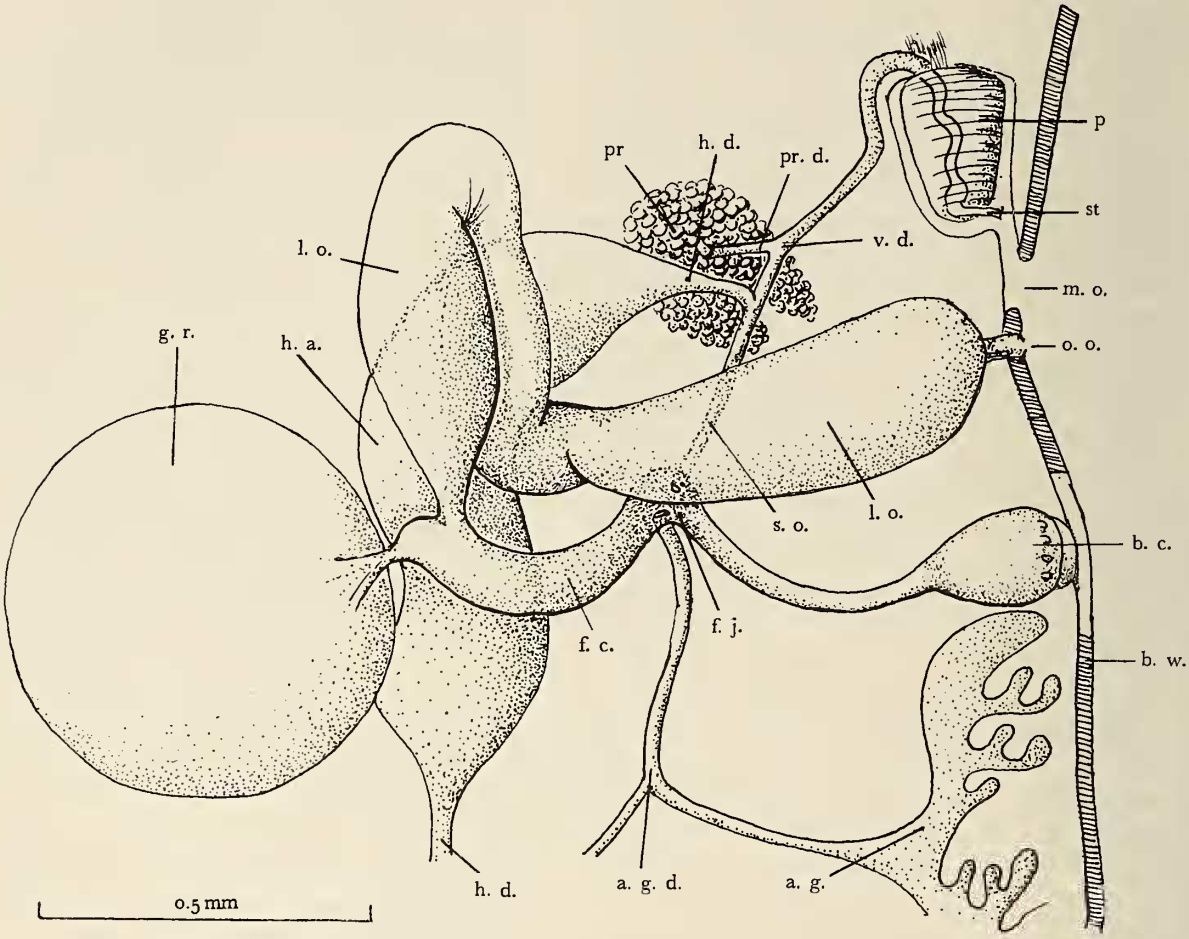

Figure 3

Reproductive system of *Olea* in the region of the fertilization canal

a. g. – albumen gland; a. g. d. – duct of albumen gland; b. c. – bursa copulatrix; b. w. – body wall; f. c. – fertilization canal; f. j. – fertilization junction; g. r. – genital receptacle (receptaculum seminis); st – penial style; h. a. – hermaphrodite ampulla (vesicula seminalis); h. d. – hermaphrodite duct; l. o. – large oviduct (capsule gland); m. o. – male opening; o. o. – oviducal opening; p – penis; pr – prostate; pr. d. – prostatic duct; s. o. – small oviduct; v. d. – vas deferens

A Functional Interpretation

Sperm route.

Sperm pass from the follicles of the ovotestis into the hermaphrodite duct (h. d.). When they reach the ampulla (h. a.) they are stored temporarily. During copulation sperm are driven forwards along the vas deferens (v. d.) and on the way secretion from the prostate (pr) is added. The style (st) pierces the body wall of the partner and delivers sperm into the bursa copulatrix (b. c.). Here they are stored till required.

Egg route.

Eggs move from the follicles into the ampulla (h. a.) and pass down the small oviduct (s. o.) to the fertilization junction (f. j.). When in the fertilization canal (f. c.), the eggs are fertilized and each is coated with albumen. They now pass into the large oviduct. Here each egg is enclosed in a capsule and then the capsules are wrapped in a coat of mucus. The egg-string passes out of the body through the oviducal opening (o. o.).

heated to about 55° C with a bench lamp and the buccal mass was observed with a stereoscopic microscope. After about an hour the radula was visible; the Azo-black had selectively stained the basis of the teeth making them easier to see.

The radula was washed and placed on a slide in a drop of water; a cover glass was not used. The radula was examined with a microscope and a 'no cover' objective of N. A. 0.65. The advantage of not using a cover glass is that glare is considerably reduced, thus allowing $\frac{3}{4}$ of the full aperture of the objective to be employed. At this stage the teeth were measured and drawn.

A permanent mount was now prepared. The radula was thoroughly washed in distilled water to remove all traces of NaOH and then dehydrated in absolute alcohol. Increased visibility was obtained by clearing in toluene and mounting in bromonaphthalin (Abbe 1880). The teeth were re-examined with an objective of N. A. 0.80 and the measurements and details of the drawing were checked.

A micro-pipette was used when transferring a radula from 5% NaOH solution to water, but for subsequent transferences a hooked needle was preferred. This was made from the finest entomological pin obtainable (No. 0065) and was mounted in a long-handled pin-holder chuck.

CONCLUSION

Olea is without doubt a sacoglossan and is closely related to the Stiligeridae and Limapontiidae. Its systematic position as given by Thiele (1931) is a tribute to his soundness of judgement, considering the knowledge then available. Now that more is known about *Olea*, the family name Oleidae might be dispensed with, and perhaps the genus *Olea* may be included in the Stiligeridae, when that complex family has been revised by taxonomic experts.

ACKNOWLEDGMENTS

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